SEPTEMBER RAINS IN THE SOUTHWESTERN UNITED STATES

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INTRODUCTION

Drought conditions existed in the Southwest during August and persisted into mid-September with maximum temperatures in the upper 90's and the 100's (°F.). However, on the evening of September 19, conditions began to change. An upper air trough located off the California coast began to move eastward. The moisture aloft associated with this advancing trough brought rains and showers from southern California to western Texas. Amounts in some higher valleys in Arizona were 1½ to 2½ inches and at lower levels 1 to 1½ inches (figs. 1, 2, 3).

RAINFALL

Topography plays an important role in rainfall in this part of the country. Elevations rise from sea level and coastal plains to mountainous areas averaging above 5000 feet in southern California. In Arizona the land rises sharply to the east and north of Phoenix to the Colorado Plateau with elevations ranging from 3000 to 7000 ft. above sea level, and peaks reaching over 12,000 ft.

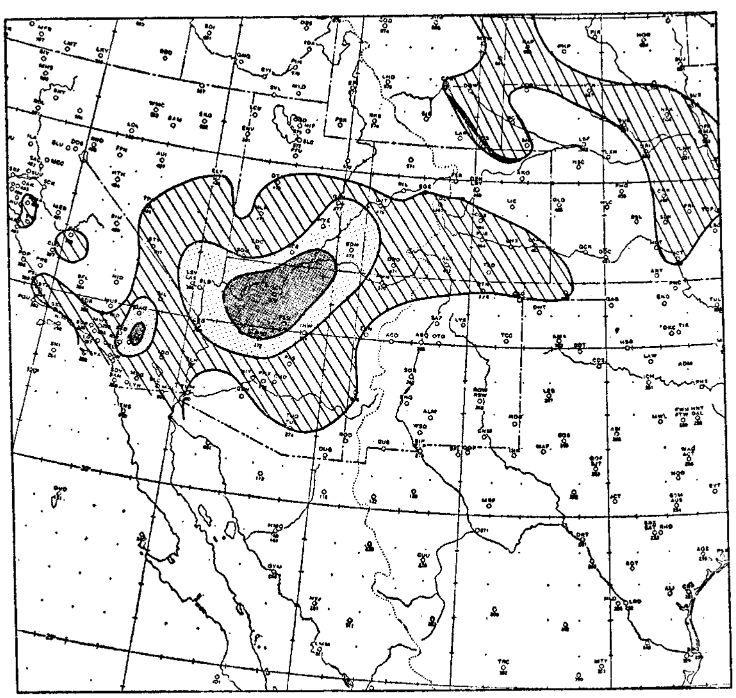

FIGURE 1—48-hour precipitation chart for the period ending 1230 GMT, September 21, 1952. Hatched area = Trace to 0.5 inch; light dot area = 0.5-1.0 inch; dark dot area = 1.0 inch and over.

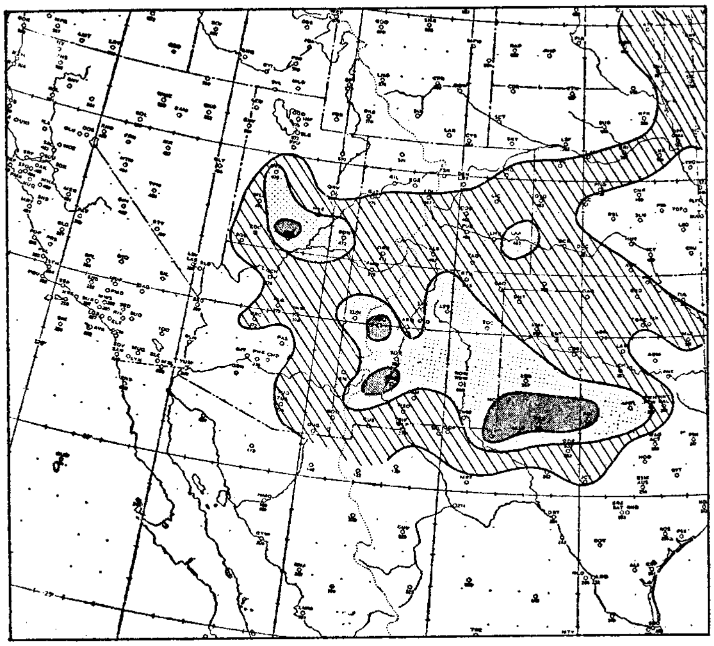

FIGURE 2—48-hour precipitation chart for the period ending 1230 GMT, September 23, 1952. Shading as in figure 1.

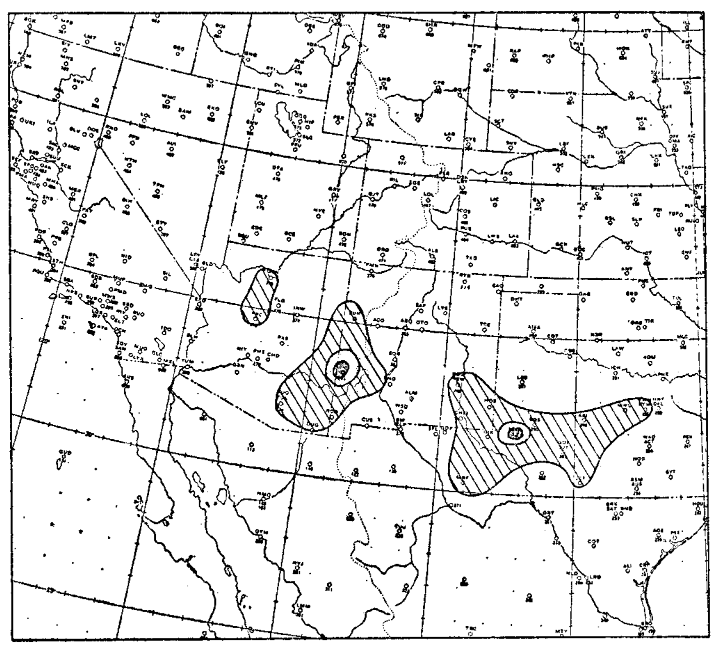

FIGURE 3—24-hour precipitation chart for the period ending 1230 GMT, September 24, 1952. Shading as in figure 1.

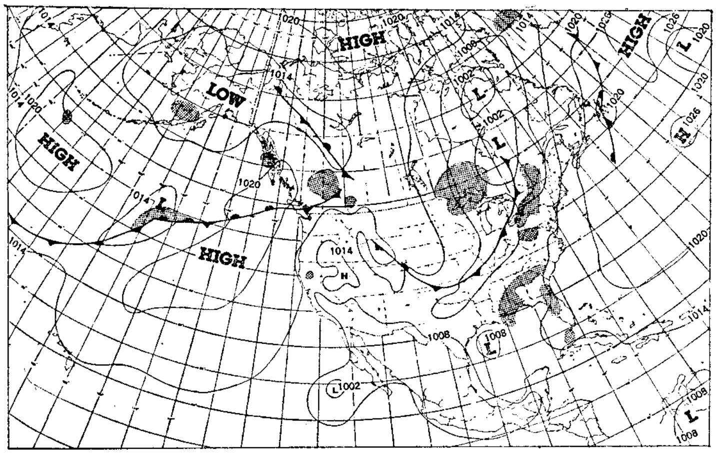

FIGURE 4—Surface weather chart, 0030 GMT, September 19, 1952. Shaded areas indicate precipitation in progress. Isobars are for intervals of 6 millibars.

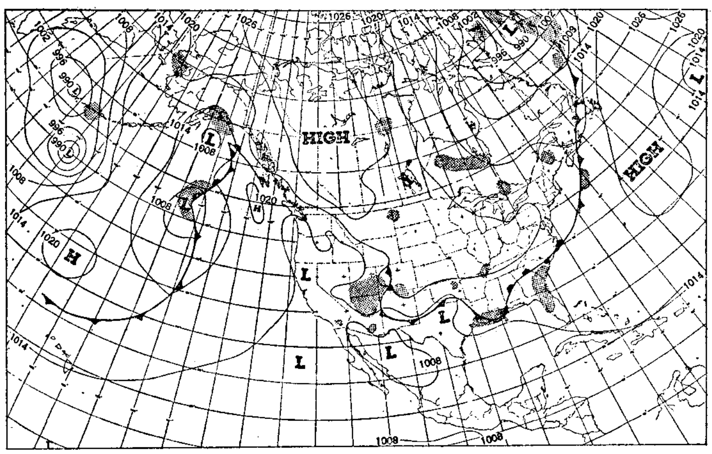

FIGURE 5—Surface chart, 0030 GMT, September 21, 1952.

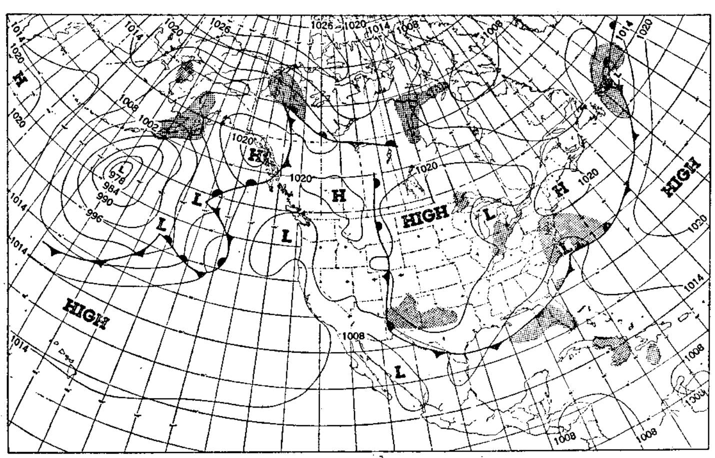

FIGURE 6—Surface chart, 0030 GMT, September 23, 1952.

With such variable terrain it can be seen that precipitation amounts will deviate considerably and the synoptic network cannot adequately describe all conditions, but the reporting network is fairly representative. Figures 1, 2, and 3 have been drawn with the use of data from this synoptic network only. A more detailed report of some of the 24-hour totals in southern California is given in table 1. Amounts vary sharply from place to place because of atmospheric instability and location of the stations with respect to topography.

TABLE 1.—*24-hour precipitation in southern California* for the period ending 0200 GMT September 20, 1952*

Los Angeles	.12	Mill Creek	1.10
Burbank	.03	Palm Springs	1.22
Capistrano	.55	Redlands	1.15
Desert Hot Springs	1.25	Redondo Beach	.09
Idyllwild	1.31	San Fernando	T
Indio	.11	Santa Monica	.01
La Jolla	T	Van Nuys	.02
Long Beach	.01	Yucaipa	1.00

*Unofficial.

The average weekly rainfall charts based on data from 1906–35 [1] show that for the first 2 weeks of September there are areas (around Death Valley) in southern California where the normal precipitation is less than 0.01 inch and for the first 3 weeks less than 0.10 inch for all of southern California. Arizona averages less than 0.10 inch in the west to 0.25 inch in the east. Eastward the rainfall increases and in Texas averages are 0.25 inch in the west to 0.99 for the eastern portion. Figures 1, 2, and 3 show that many areas in the Southwest received more than the normal precipitation for all of September during the 5-day period from September 19 to 23.

GENERAL SYNOPTIC FEATURES

Normally over the Southwest in the summer months and early fall there exists a distinct thermal Low [2]. Figure 4 shows this feature with higher pressures existing to the north over Nevada and southeastern Oregon. A cold front extended from the tip of Hudson Bay, through Tulsa, Okla., to northwest Wyoming. Several days later this front became an important factor in producing precipitation in New Mexico and Texas. Normal maximum temperatures in the upper 90's and 100's were being reported in the Southwest at this time. However, the surface weather map indicated that an unusually large amount of moisture was present. For example, Yuma, Ariz., had a dew point of 73° F.

As the rains began in California the surface temperatures were lowered and the thermal Low retreated southward until it was south of the Mexican border (fig. 5). With the movement of the precipitation pattern eastward and the return of high surface temperatures, the thermal Low re-established itself over the Southwest. By 0030 GMT September 23 the cold front had become stationary and was lying along the western borders of New Mexico and Colorado (fig. 6).

In the upper air, figure 7, a high pressure ridge was centered along the Washington and Oregon coasts with the zone of maximum winds flowing across the top of this ridge into the trough in the center of the country. A subtropical High was located over Arizona and New Mexico. A trough was oriented in a north-south direction at the 700-mb. level along the California coast and associated with it was a tropical disturbance which had moved

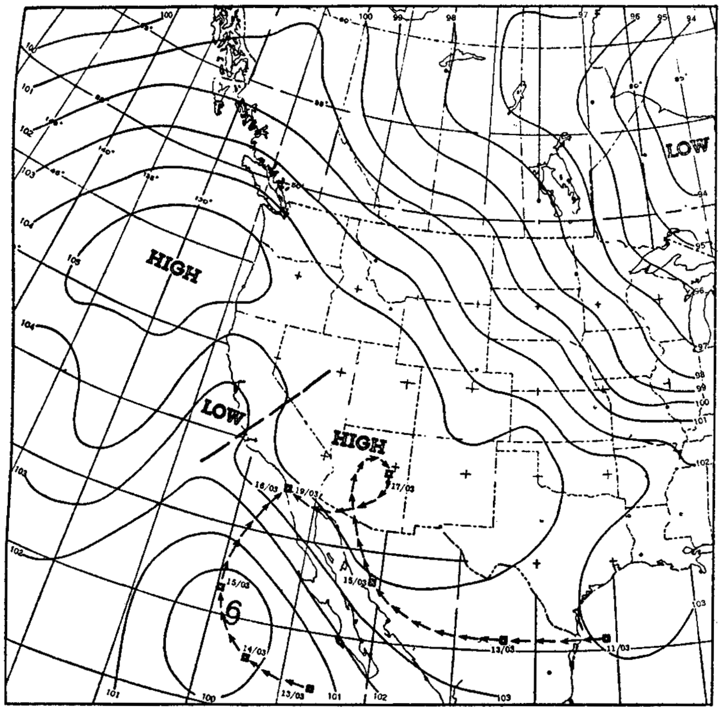

FIGURE 7—700-mb. chart, 0300 GMT, September 19, 1952. Contours at 100-ft. intervals are labeled in hundred of geopotential feet. The arrows indicate the trajectories of the moist air. Plotted number groups indicate date and time (Date/GMT) of positions.

northwestward off the coast of Baja California. At the 500-mb. level there was one closed Low situated in the Oakland area and another over the surface position of the tropical disturbance. By 0300 GMT September 21 (fig. 8) the high center had moved inland over the Pacific Northwest, the northern end of the trough moved into western Utah, and the subtropical High remained over Texas. On September 23, figure 9, the trough was oriented in an east-west direction separating the subtropical High, which remained over the northern Mexico-southern Texas area, and the high center over the Northwest.

In September the surface dew points in the southwestern United States are usually below 60°, but occasionally maritime tropical air from the Gulf of Mexico crosses the mountains of Mexico to bring in surface dew points of about 70° F. For the Southwest, another source of moisture through a thick layer of the atmosphere is a tropical storm along the west coast of Baja California. Table 2 shows the marked surface dew point variations at several Arizona stations during the week of September 15 to 21. Note especially on September 19 the high dew point at Yuma, and on September 21 the high dew points at Phoenix and Tucson.

THE FLOW OF MOISTURE

In the first part of September the air flow at the 700-mb. level across southern California, Utah, Nevada, and Arizona was from the southwest and was characterized by marked dryness [3]. But during the latter part of the month the 700-mb. flow shifted to the southeast and

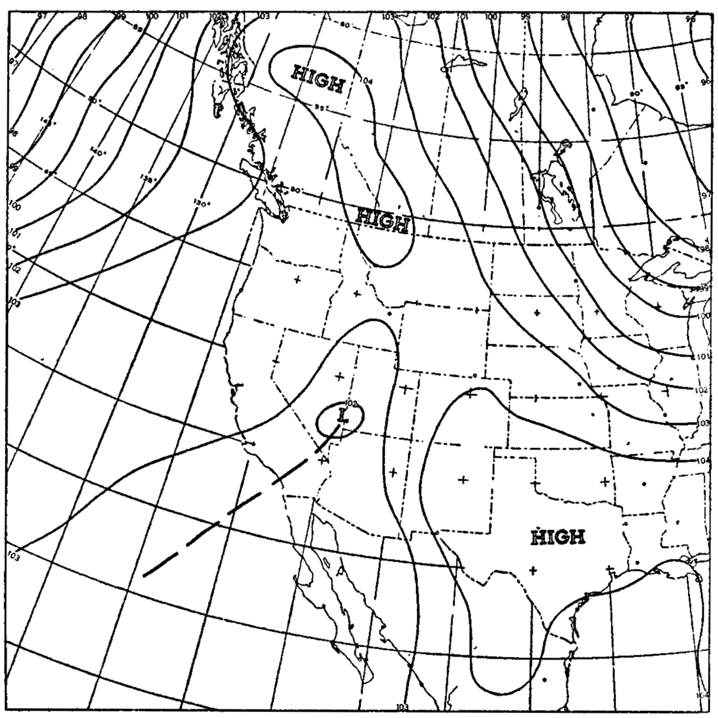

FIGURE 8—700-mb. chart, 0300 GMT, September 21, 1952.

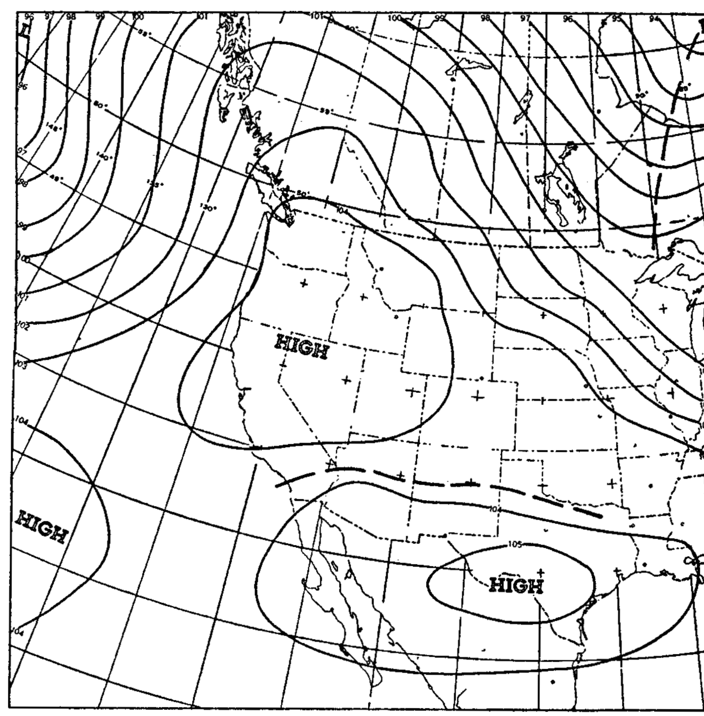

FIGURE 9—700-mb. chart, 0300 GMT, September 23, 1952.

TABLE 2.—*Surface dew point temperatures (°F), 0630 GMT, September 15–21, 1952*

Station	September						
	15	16	17	18	19	20	21
Yuma	39	53	70	71	73	63	59
Phoenix	51	50	56	61	61	61	69
Tucson	42	41	45	55	57	58	65

brought in moist air. Forecasters usually look for tropical maritime air at or above 700 mb. for the first indications of widespread summer rains in the southwestern United States. Air coming from the southeast tends to be moist and unstable while a southwest flow over this region is ordinarily associated with dry, stable, subsiding air.

Precipitation depends chiefly on a supply of moisture and a lifting mechanism, often a front or a mountain range. From September 10–14 a well defined cold front passed through the southwestern United States accompanied by sharp temperature falls amounting to as much as 10° C. at the 700-mb. level and marked wind shifts. But only scattered showers accompanied the passage of the front for the air was very dry. At Las Vegas, Nev., for example, the temperature-dew point difference at 1500 GMT September 10 was 29° C. at 850 mb. and over 22° C. at 700 mb. A different situation came into existence on September 16 when moist air arrived over southern California from a tropical storm about 900 miles south-southeast of San Diego, Calif. The trajectory [1] of

[1] The trajectory was constructed by estimating an average wind speed and direction at the 700-mb. level for the 6-hr. period before and after the time of the chart. The parcel, from the tongue of the moist air, was then moved ahead to the point given by this average wind. The procedure was repeated for each new position (see [4]).

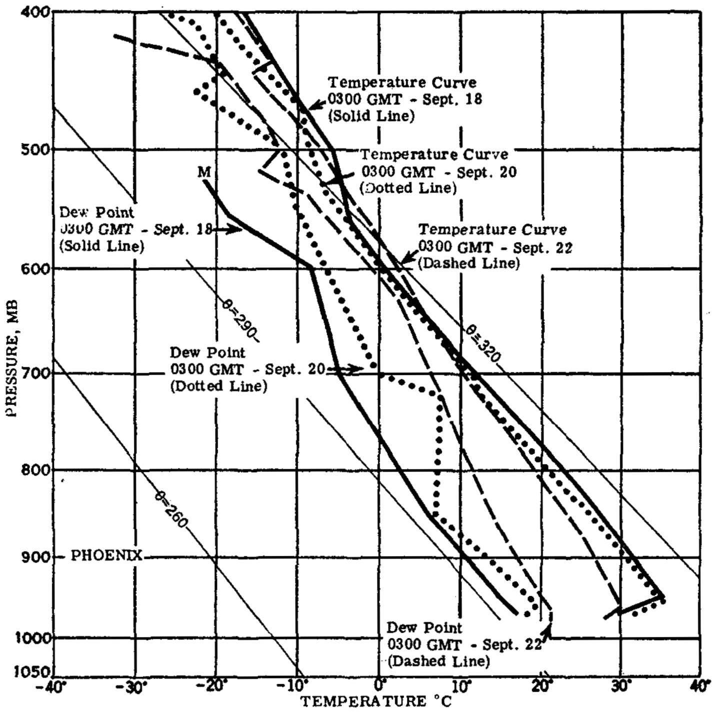

FIGURE 11—Upper air soundings over Phoenix, Ariz.

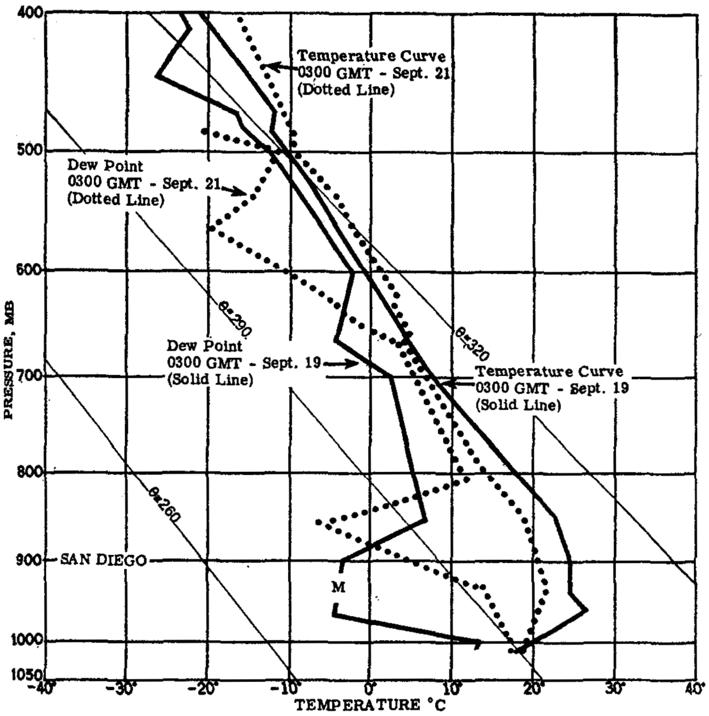

FIGURE 10—Upper air soundings over San Diego, Calif. "M" on the dew-point curve indicates missing data due to "motorboating" (failure of the radiosonde instrument to record accurately due to the low moisture content of the air).

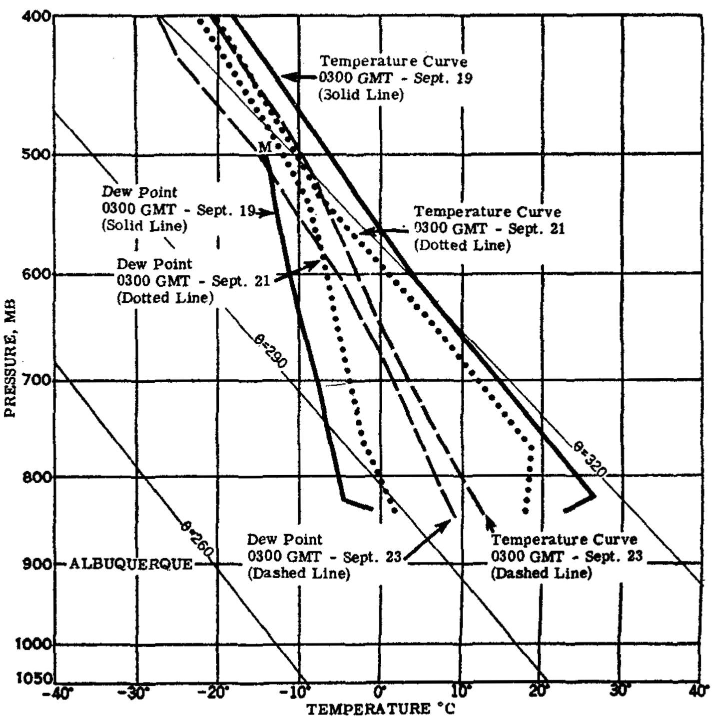

FIGURE 12—Upper air soundings over Albuquerque, N. Mex.

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the moisture at 700 mb. is shown in figure 7 (western trajectory). Since there was little temperature variation at 700 mb. during this period, the trajectory may also be thought of as indicating the flow of moisture on an isentropic surface. Again, there was no rain in the Southwest. This time the moisture present over San Diego was in a thin layer between the 590- and 730-mb. levels with marked dry air above and below. There was no frontal structure present. The lift required to saturate this moist layer would be about 5,000 feet and this could be supplied by the mountain ranges in the region. If precipitation formed in the saturated layer (after lifting) it was probably evaporated in falling thru the dry air below. Also mixing of the layer would tend to lower the dew-point temperatures in the already thin moist layer and further discourage the formation of rain.

However, beginning on the 19th, the proper combination of moisture and lift finally became available. On this date moisture, which had its origin over the Gulf of Mexico (near Brownsville, Tex.) about a week earlier combined, over San Diego, Calif., with the large amount of moisture associated with the tropical disturbance which was centered off the coast of Baja California. Simultaneously a sharp 700-mb. trough (fig. 7), associated with a deep Low that extended up to at least the 300-mb. level, moved through that area. Convergence into this trough provided the necessary lift. As the moisture and lifting mechanism moved along, heavy rains fell in southern California, southern Nevada, Arizona, and south and central Utah. The results of the radiosonde observations for San Diego, Calif., Phoenix, Ariz., and Albuquerque, N. Mex. from September 18-23, 1952, are shown in figures 10, 11, and 12. They all show regions of very low stability through considerable depths of the atmosphere, and at the same time they show unusually high dew points to great heights.

On the 22d, the trough and Low aloft became very weak but now a new lifting mechanism entered the picture. This took the form of the cold front which had been pushing southward and westward through the central United States in the past few days. On the 23d (fig. 6) it was located near the western borders of Colorado and New Mexico. Moderate to heavy rain fell in New Mexico on the 22d and 23d for two reasons: first, the warm, moist air from the southwest, originally from the south, was lifted in flowing over the front, and second, the cool air itself was lifted several thousand feet as it arrived over New Mexico from the Plains. On September 24, only scattered showers were observed in Texas and as the cold front moved south into the Gulf of Mexico the rains in the Southwest ended.

ACKNOWLEDGMENT

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